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Nanoengineered Surfaces with Tunable Water Adhesion Properties and Their Applications for Microdroplet Arrays

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Abstract Body

Tuning liquid-surface adhesion has attracted huge research interests due to its promising applications ranging from self-cleaning surfaces to microarrays and further.[1,2] Following Wenzel, Cassie, and Baxter, an approach to alter *surface wetting properties* is to introduce roughness hereon. Rough surfaces comprising nanoscale cones can easily be produced with a reactive ion etch by the one-step "black silicon method". Tuning the etching process parameters, such as gas flow rate and etching time, allows for alternation of cone height and cone opening angle.[3]

We covered such a surface with a self-assembled monolayer of perfluorodecyltrichlorosilane to render it hydrophobic and systematically studied the macroscopic surface wetting properties as a function of the cone opening angles. The surface adhesion is found to depend critically on the cone opening angle, and can easily be tuned from highly water-repellent to complete pinning of the droplets.[4] Thus, the one-step fabricated surfaces can exhibit both the lotus effect and the rose petal effect.

The ability to tune the surface wettability opens up for a vast amount of applications, and here we develop a few related to the field of microdroplet arrays. First, we show how the microstructure-induced advancing contact angle on a rose petal surface can be exploited to create self-alignment of pipetted droplets.[5] Secondly, by superimposing the lotus effect roughness on a chemical pattern we enhance the adhesive properties to create a super-biphilic array chip. We find that such a chip in a dip-coating process will entrain droplets with sizes tunable through the dip-coating parameters. Lastly, the nanograss geometry alters the nucleation point density for vapor condensation and opens up for applications within spatial control hereof. In relation to this, we demonstrate spatial control of condensation on chemically homogeneous pillar-built surfaces.[6] Currently, the success depends on the water vapor introduction, but this restriction could potentially be depressed using spatially confined nanograss.

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